What is a Part Per Million?

Grades

Secondary

Subjects

Science – (chemistry)

Type of Lesson Plan

Lab

Suggested Duration

45 minutes

Materials

- Small paper cups, Styrofoam egg cartons, or small test tubes (7 containers per group) Make sure the inside of the containers are white, or in the case of clear containers, place them over white sheets of paper.
- Graduated cylinder
- Test tube rack
- Eye droppers
- Food coloring (blue works best)
- Make an overhead of the *Parts Per Million Comparison Shee*"
- Consumer Confidence Report from your local Public Water System overhead (one is included if you can not obtain your own)
- Lab sheet copies

Objectives

TLW…

- Observe the difficult to grasp concept of a part per million.
- Understand that very small amounts of pollution (l part per million or less) can cause adverse health effects in humans.
- Appreciate the role chemistry plays in protecting human health.

Set

Bring in a copy of your local public water system's Consumer Confidence Report (mailed out annually and available from your local drinking water supplier) or use the example provided with this activity. Turn the report into an overhead and go through the results with your students. The reports list the chemicals present in your drinking water. These results are generally reported in parts per million or the equivalent milligrams per liter (mg/L). Ask your students to try and visualize a part per million. It is difficult. Show them the *Parts Per Million Comparison Sheet* overhead. Go through some examples. Now inform the students that they will be going through a lab that will produce 1 part per million of “pollutant” in tap water.

Instructional Input

Place the students in groups of 4, hand out the lab sheet, make the appropriate materials available, and go over the procedure with the class. Allow them to work on the lab. Check their math as you observe their progress. Allow them time to work on the questions before ending the lab. After the lab is over, go over the answers to the lab questions and the follow up questions at the end. Discuss the feasibility of the designed experiments.

Evaluation

Grade the lab sheets individually or as a class as you prefer. A lab key is provided.

Closure

Make sure to discuss the last paragraph on the lab sheet. Many times students question the relevancy of material taught in school. “How does this relate to me?” or “How can I use this in real life?” The ability to grasp the concept of small concentrations is important to understanding the role of environmental contaminants in human health. This lab also shows the importance of chemistry in the protection of human health.

A Part Per Million Lab Sheet

Names_______________________Period________Date___________________

Obtain the following materials:

- 7 empty containers
- eye dropper
- tap water
- food coloring

Step 1

Place 1 mL of food coloring into one of your empty containers.
Pour some tap water into another of your empty containers.
The food coloring is a 10% solution of dye and water.
How many parts of water are there for every part of dye?

______________ parts of water for every part of food coloring

Step 2

Rinse the eye dropper. Using the eye dropper, place 9 drops of tap water into an empty container, then place one drop of food coloring into this same container. Stir your new solution. Observe the color difference between the 10% food coloring and the solution you just created. You have changed the amount (concentration) of the food coloring. There is 10 times less food coloring per water than there was in the original food coloring solution.

Now there are ______________ parts of water for every part of food coloring in your new solution.

Step 3

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____ times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Step 4

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Step 5

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Step 6

Rinse the eye dropper. Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is ____ times less food coloring per water in the new solution than there was in the original food coloring solution. There are now __________ parts of water for every part of food coloring in your new solution.

Answer the questions below in complete sentences.

1. In which step did your solution appear to be clear?

2. Was there still food coloring in the solutions that appeared to be clear? How do you know?

3. Describe an experiment you could use to prove the presence or absence of food coloring in the clear solutions.

The US Environmental Protection Agency has placed a limit of **0.01 parts per million** (or 10 parts per billion) of arsenic in drinking water. That is 1% of the concentration (or 100 times less) of food coloring in your solution in step six! So you see, very small concentrations of pollutants, so small you can't detect them by sight, can cause harm to human health. This is one reason chemical laboratory work is important. Chemistry is used to protect human health.

A Part Per Million Lab Sheet

Names ____KEY__________

Obtain the following materials:

- 7 empty containers
- eye dropper
- tap water
- food coloring

Step 1

Place 1 mL of food coloring into one of your empty containers.
Pour some tap water into another of your empty containers.
The food coloring you added to the water is a 10% solution of dye and water.
How many parts of water are there for every part of dye?

_____10_________ parts of water for every part of food coloring

Step 2

Using the eye dropper, place 9 drops of tap water into an empty container, then place one drop of food coloring into this same container. Stir your new solution. Observe the color difference between the %10 food coloring and the solution you just created. You have changed the amount (concentration) of the food coloring. There is 10 times less food coloring per water than there was in the original food coloring solution.

Now there are **___100___________** parts of water for every part of food coloring in your new solution.

Step 3

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is **_100** times less food coloring per water in the new solution than there was in the original food coloring solution. There are now **___1000____** parts of water for every part of food coloring in your new solution.

Step 4

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is **1,000 times** less food coloring in the new solution than there was in the original food coloring solution. There are now **__10,000__** parts of water for every part of food coloring in your new solution.

Step 5

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is **10,000 times** less food coloring in the new solution than there was in the original food coloring solution. There are now **_100,000** parts of water for every part of food coloring in your new solution.

Step 6

Using the eye dropper, place 9 drops of water into another empty container, then place one drop of the solution you created in the previous step into this new container. Stir your new solution. Observe the color difference between your new solution and the one you created in the previous step. You have changed the concentration of the food coloring in the water again.

There is **100,000 times** less food coloring in the new solution than there was in the original food coloring solution. There are now **_1,000,000** parts of water for every part of food coloring in your new solution.

Answer the questions below in complete sentences.

1. In which step did your solution appear to be clear?

   This would certainly occur in step six, possibly earlier depending on observational skills.

2. Was there still food coloring in the solutions that appeared to be clear? How do you know?

   There was still food coloring even though it was not visible. The concentration was very low, but it was still there. The food coloring has to be there because no chemical or physical process removed it.

3. Describe an experiment you could use to prove the presence or absence of food coloring in the clear solutions.

   The containers could be left out under a heat lamp, causing the water to evaporate. This would leave the food coloring dye behind.

The US Environmental Protection Agency has placed a limit of **0.01 parts per million** of arsenic in drinking water. That is 1% of the concentration (or 100 times less) of food coloring in your solution in step six! So you see, very small concentrations of pollutants, so small you can't detect them by sight, can cause harm to human health. This is one reason chemical laboratory work is important. Chemistry is used to protect human health.

Part Per Million Comparison

One part per million is one minute in two years.

One part per million is one second in 12 days of your life.

One part per million is one penny out of $10,000.

One part per million is one inch out of a journey of 16 miles.

One part per million is approximately one hole in one in 35,000 golf tournaments.

One part per million is approximately one bad apple in 2,000 barrels of apples.

One part per million is one drop of dye in 18 gallons of water.

National Primary Drinking Water Regulations

Inorganic Chemicals	MCL (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Antimony	0.006	Increase in blood cholesterol; decrease in blood glucose	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder
Arsenic	0.05	Skin damage; circulatory system problems; increased risk of cancer	Erosion of natural deposits; runoff from glass & electronics production wastes
Beryllium	0.004	Intestinal lesions	Metal refineries and coal-burning factories; discharge from electrical industries
Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; waste batteries and paints
Chromium (total)	0.1	Over many years could experience allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits
Copper	1.3	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage.	Corrosion of household plumbing systems; erosion of natural deposits

Inorganic Chemicals	MCL (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories
Fluoride	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth.	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories
Lead	0.015	Infants and children: Delays in physical or mental development. Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits
Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and cropland
Nitrate (measured as Nitrogen)	10	"Blue baby syndrome" fatal without immediate medical attention. Infant looks blue and has shortness of breath.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits

Inorganic Chemicals	MCL (mg/L)[2]	Potential Health Effects from Ingestion of Water	Sources of Contaminant in Drinking Water
Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines
Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and pharmaceutical companies

Notes

Definitions:

Maximum Contaminant Level (MCL) - The highest level of a contaminant that is allowed in drinking water. MCLs are enforceable standards.

Treatment Technique - A required process intended to reduce the level of a contaminant in drinking water.

[2] Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million.